Making the Business Case for Open and Virtualized RAN

How to save money in the radio access network

intel

Contents

Open and virtualized RAN are set for rapid growth

Open and virtualized radio access network (Open vRAN) technologies could grow to nearly 10 percent of the total RAN market by 2025, according to estimates from Dell'Oro Group[1]. That represents a rapid growth, given that Open vRAN only makes up one percent of the RAN market today.

There are two facets to Open vRAN:

- **Virtualization** disaggregates the software from the hardware and enables RAN workloads to run on general-purpose servers. General-purpose hardware is more flexible and easier to scale than appliance-based RAN. It's relatively easy to add new RAN functionality and performance enhancements using a software upgrade. Proven IT principles such as software-defined networking (SDN), cloud-native, and DevOps can be used. There are operational efficiencies in how the network is configured, reconfigured, and optimized; as well as in fault detection, correction, and prevention.

- **Open interfaces** enable Communications Service Providers (CoSPs) to source the ingredients of their RAN from different vendors and integrate them more easily. Interoperability helps to increase competition in the RAN both on price and features.

Virtualized RAN can be used without open interfaces, but the benefits are greatest when both strategies are combined.

Interest in vRAN has been increasing recently, with many operators engaging in trials and their first deployments. Deloitte estimates there are 35 active Open vRAN deployments worldwide[2]. Intel's FlexRAN software architecture for baseband processing is being used in at least 31 deployments worldwide (see Figure 1).

In this paper, we explore the business case for Open vRAN. We'll discuss the cost benefits of baseband pooling, and the strategic reasons why Open vRAN is still desirable when pooling isn't possible.

Figure 1: Virtualized radio access network (vRAN) deployments are happening worldwide, powered by Intel's FlexRAN software architecture.

Introducing a new RAN topology

In the traditional Distributed RAN (DRAN) model, the RAN processing is carried out close to the radio antenna.

Virtualized RAN splits the RAN into a pipeline of functions, which can be shared across a distributed unit (DU) and a centralized unit (CU). There are a number of options for splitting up the RAN, as shown in Figure 2. Split Option 2 hosts the Packet Data Convergence Protocol (PDCP) and Radio Resource Control (RRC) in the CU, while the rest of the baseband functions are carried out in the DU. The PHY function can be split between the DU and the Remote Radio Unit (RRU).

The advantages of split RAN architectures are:

- Hosting the Low-PHY function at the RRU reduces the fronthaul bandwidth requirement. In 4G, Option 8 splits were commonly used. With 5G, the bandwidth increase makes Option 8 unviable for 5G standalone (SA) mode. (5G non-standalone (NSA) deployments can still use Option 8 as legacy).
- The quality of experience can be improved. When the core control plane is distributed to the CU, the CU becomes the mobility anchor point. As a result, there are fewer handovers than there are when the DU is the anchor point[3].
- Hosting the PDCP at the CU also helps to balance the load when supporting the dual connectivity (DC) capability of 5G in an NSA architecture. Without this split, user equipment would connect to two base stations (4G and 5G) but only the anchor base station would be used to process the streams through the PDCP function. Using split Option 2, the PDCP function happens centrally, so the DUs are more effectively load balanced[4].

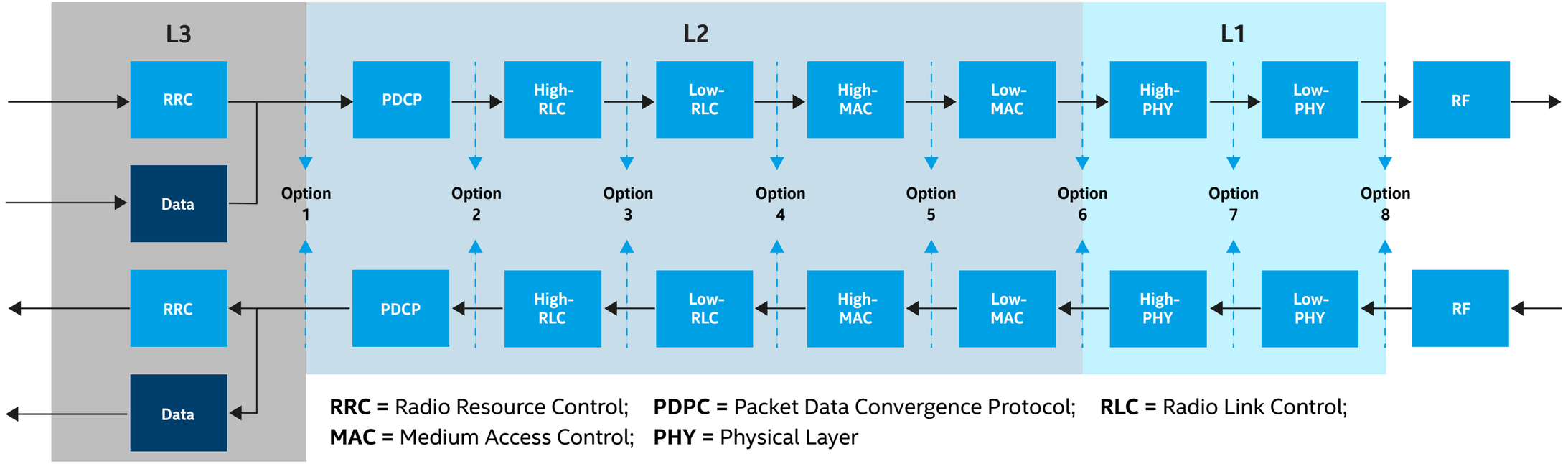


Figure 2: Split architectures for the radio access network (RAN) divide the RAN's functions between the remote radio unit (RRU), distributed unit (DU), and centralized unit (CU).

Reducing costs through baseband pooling

One way that Open vRAN can help to reduce costs is by pooling baseband processing. One CU can serve multiple DUs, and the DUs can be located with the CUs for cost efficiencies. Even if the DU is hosted at the cell site, there can be efficiencies because the DU can serve multiple RRUs, and the cost per bit reduces as the cell capacity grows[5]. Software running on commercial off-the-shelf hardware can be more responsive, and scale more flexibly, than dedicated hardware that requires manual labor to scale and configure.

Baseband pooling is not unique to Open vRAN: in traditional custom RAN, the baseband units (BBUs) have sometimes been grouped in more centralized locations, called BBU hotels. They are connected to the RRUs over high-speed fiber. It reduces the cost of equipment at the site and reduces the number of truck rolls for installing and servicing equipment. BBU hotels offer limited granularity for scaling, though. The hardware BBUs do not have all of the resource optimization advantages of virtualization, nor the flexibility for handling multiple and varying workloads.

Our own work with CoSPs found that the top operating expenditure (OPEX) cost in the RAN is BBU software licensing. More efficient software reuse through pooling helps to optimize the total cost of ownership (TCO) for the RAN.

However, the cost of transport needs to be considered. The backhaul for traditional DRAN has typically been a leased line provided to the mobile network operator by fixed network operators. Leased lines can be expensive, and the cost has a decisive effect on the business plan for where the DU should be located.

Consultancy firm Senza Fili and vRAN vendor Mavenir modeled the costs based on trials conducted with customers of Mavenir, Intel, and HFR Networks[6]. Two scenarios were compared:

1. DUs are located with the RRUs at the cell sites. Midhaul transport is used between the DU and the CU.

2. DUs are located with the CUs. Fronthaul transport is used between the RRUs and DU/CU.

The CU was in a data center where hardware resources could be pooled across RRUs. The study modeled the costs of the CU, DU, and midhaul and fronthaul transport, covering both OPEX and capital expenditure (CAPEX) over a six-year period.

Centralizing the DU increases the transport costs, so the question was whether the pooling gains outweigh the transport costs. The study found:

- Operators with low-cost transport to most of their cell sites are better off centralizing the DU with the CU. They can cut their TCO by up to 42 percent.
- Operators with high transport costs can cut their TCO by up to 15 percent by hosting the DU at the cell site.

The relative cost savings also depend on the cell capacity and the spectrum used. A DU at a cell site, for example, may be underused and could scale to support more cells or higher bandwidth at the same cost.

It may be possible to centralize RAN processing up to 200km from the radio site in the "Cloud RAN" model. A separate Senza Fili and Mavenir study[7] found that Cloud RAN could lower costs by 37 percent over five years, compared to DRAN. BBU pooling and more efficient use of hardware help to drive down costs. OPEX savings come from lower maintenance and operations costs. Centralized locations are likely to be easier to access and manage than the cell sites are, and cell sites can also be smaller because there is less equipment required there.

Virtualization and centralization together make it easier to scale as traffic demands change. It's easier to add more general-purpose servers to the resource pool than it is to upgrade proprietary hardware at the cell site. CoSPs can better match their hardware expenditure to their revenue growth, without needing to deploy hardware now that will be able to manage the traffic in five years' time.

How much of the network to virtualize?

ACG Research and Red Hat compared the estimated total cost of ownership (TCO) for a Distributed radio access network (DRAN) and virtualized RAN (vRAN)[8]. They estimated the capital expenditure (CAPEX) of vRAN was half that of DRAN. This was mainly down to cost efficiencies from having less equipment at fewer sites using centralization.

The study also found that the operating expenditure (OPEX) was significantly higher for DRAN than vRAN. This was a result of reduced site rental, maintenance, fiber lease, and power and cooling costs.

The model was based on a Tier 1 Communications Service Provider (CoSP) with 12,000 base stations now, and a need to add 11,000 over the next five years. Should the CoSP virtualize the entire RAN, or just the new and expanded sites? ACG Research found that the TCO savings were 27 percent when only new and growth sites were virtualized. TCO savings increased to 44 percent when all sites were virtualized.

27%
TCO saving

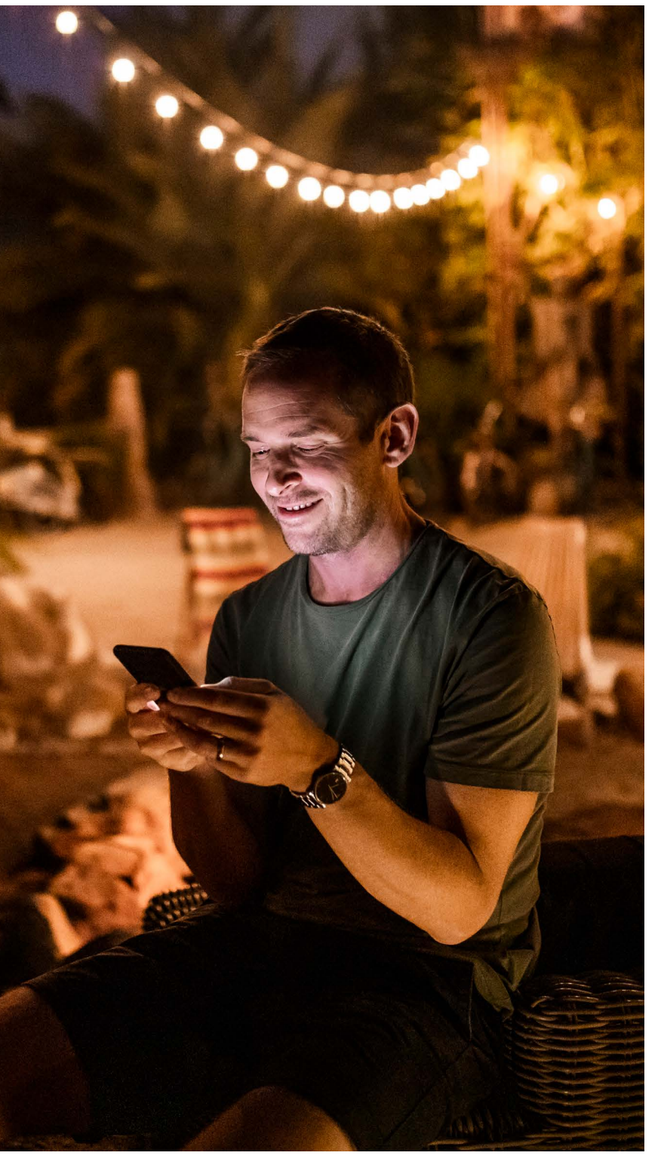
Virtualizing just new and expanded RAN sites

44%
TCO saving

Virtualizing all RAN sites

ACG Research. Based on a network of 12,000 sites with plans to add 11,000 over the next five years.

The case for Open vRAN at the cell site



Some CoSPs adopt Open vRAN at the cell site for strategic reasons, even when baseband pooling does not deliver cost savings.

Creating a flexible cloud-based network

One CoSP we spoke to stressed the importance of being able to place network functions wherever they give the best performance for a particular network slice.

This becomes possible when you use general-purpose hardware throughout the network, including for the RAN. The user plane function, for example, could be moved to the RAN site at the edge of the network. This significantly cuts latency. Applications for this include cloud gaming, augmented reality/virtual reality, or content caching.

General-purpose hardware may be used for other applications when the RAN has low demand. There will be busy hours and quiet hours, and the RAN will in any case be overprovisioned to cater for future traffic growth. The spare capacity on the server could be used for a cell site Internet of Things workload, or for a RAN Intelligent Controller (RIC), which optimizes radio resource management using artificial intelligence and machine learning.

More granular sourcing can help to drive down costs

Having open interfaces gives operators the freedom to source components from anywhere. It increases competition between the traditional telecom equipment vendors, but that's not all. It also gives operators the flexibility to source from hardware manufacturers who have not previously sold directly into the network. Interoperability opens up the market to new vRAN software companies, too, that can bring innovations and increase price competition.

Operators may be able to achieve lower costs by sourcing components, in particular the radio, directly, rather than buying them through a telecom equipment manufacturer (TEM). The radio accounts for the largest share of the RAN budget, so cost savings here can have a significant impact on overall costs. The BBU software license is the primary OPEX cost, so increased competition in the RAN software layer helps to drive down ongoing costs.

At Mobile World Congress 2018, Vodafone Chief Technology Officer Johan Wibergh spoke about the company's six-month Open RAN test in India. "We have been able to reduce the cost to operate by more than 30 percent, using a much more open architecture, by being able to source components from different pieces," he said[9].

30%
cost saving

From sourcing components separately.

Vodafone's Open RAN trial, India

Building a platform for new services

Having general-purpose compute capabilities at the edge of the network also enables CoSPs to host customer-facing workloads there. As well as being able to host workloads extremely close to the user, CoSPs are able to guarantee performance. This can help them to compete with cloud service providers for edge workloads.

Edge services require a distributed cloud architecture, backed with orchestration and management. This can be enabled by having a fully virtualized RAN operating with cloud principles. Indeed, virtualizing the RAN is one of the drivers for realizing edge computing.

Intel® Smart Edge Open software provides a software toolkit for Multi-Access Edge Computing (MEC). It helps to achieve highly optimized performance, based on the hardware resources available wherever the application runs.

CoSPs' edge services could be attractive for applications requiring low latency, consistent performance, and high levels of reliability.

Consistency helps to drive down costs

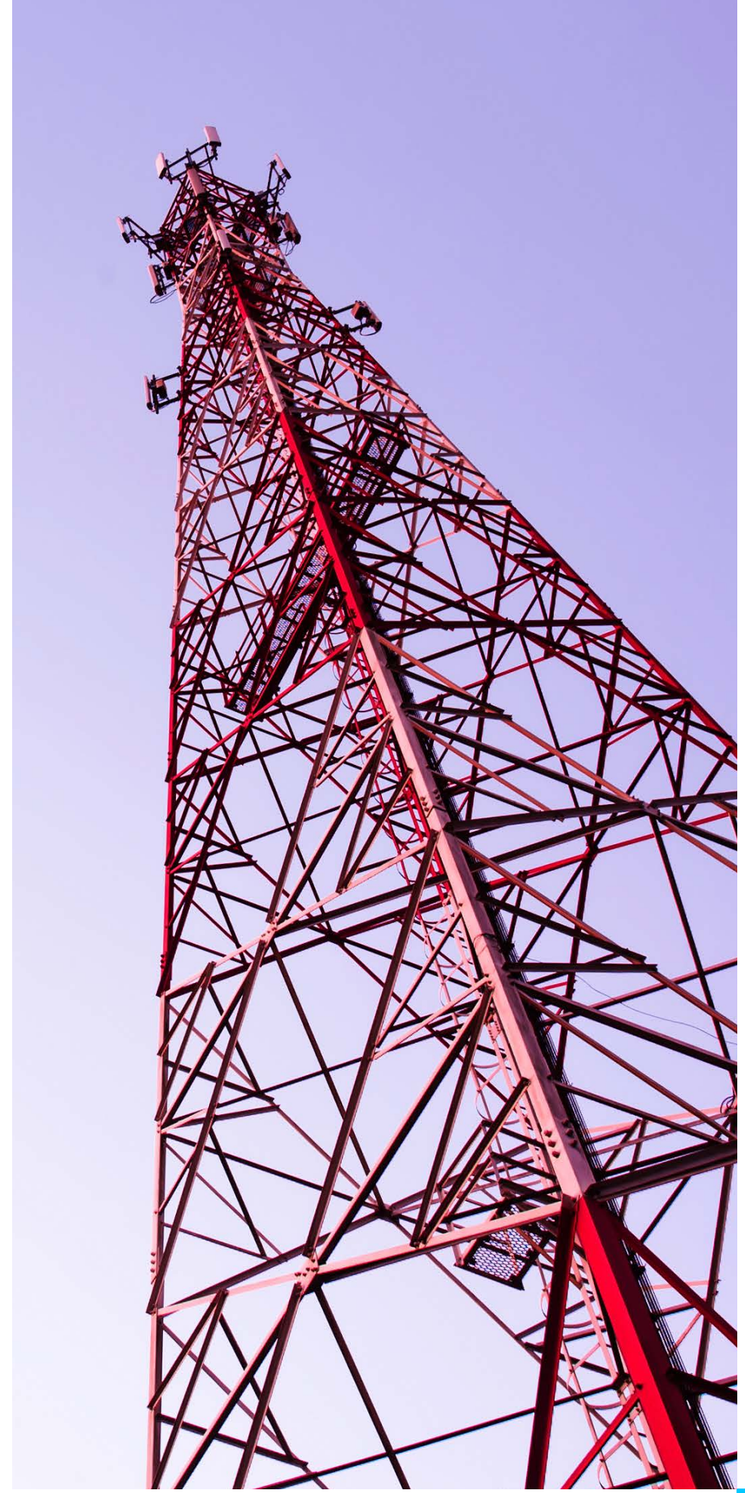
Virtualization can deliver cost savings, even in sites where baseband pooling cannot be used. There are benefits to the CoSP and the RAN estate as a whole in having a consistent architecture.

Having a single software and hardware stack simplifies maintenance, training, and support. Common tools can be used to manage all sites, without needing to differentiate between their underlying technologies.

Preparing for the future

Moving from DRAN to a more centralized RAN architecture will take time. Updating the RAN at the cell site to Open vRAN is a good stepping stone. It enables a consistent software architecture to be introduced early, so that suitable sites can be more easily centralized in the future. The hardware deployed at the cell sites can be moved to the centralized RAN location or used for other edge workloads, making today's investment useful in the long run.

The economics of mobile backhaul may change significantly in the future for some or all of the CoSP's RAN sites, too. Sites that are not viable for centralized RAN today might be more viable if cheaper fronthaul connectivity becomes available. Running virtualized RAN at the cell site enables the CoSP to centralize later if that becomes a more cost-effective option.



Calculating the total cost of ownership (TCO)

While cost is not the primary motivation for adopting Open vRAN technologies in many cases, there can be cost savings. So much depends on the specific deployments. No two operator networks are alike. Within each network, there is huge diversity across cell sites. A network topology that works for densely populated urban areas might not be suitable for rural areas. The spectrum that a cell site uses will have an impact on the bandwidth required, which will affect the fronthaul costs. The transport options available for fronthaul have a significant impact on the cost model.

The expectation is that in the long term, using Open vRAN may be more cost effective than using dedicated hardware, and will be easier to scale.

Accenture has reported seeing CAPEX savings of 49 percent where Open vRAN technologies have been used for 5G deployments[10]. Goldman Sachs reported a similar CAPEX figure of 50 percent, and also published cost savings of 35 percent in OPEX[11].

At Intel, we are working with leading CoSPs to model the TCO of Open vRAN, including both CAPEX and OPEX. While the CAPEX is well understood, we are keen to see more detailed research on how the operating costs of vRAN compare with dedicated appliances. We are working with the Open vRAN ecosystem to explore this further.

50%
CAPEX saving

from Open vRAN

35%
OPEX saving

from Open vRAN

Goldman Sachs

Using Open RAN for all wireless generations

The introduction of 5G is the catalyst for a lot of change in the radio access network (RAN). 5G services will be bandwidth-hungry and are still emerging, making a more scalable and flexible architecture highly desirable.

An Open and virtualized radio access network (Open vRAN) may make 5G easier to deploy in greenfield networks, but few operators are starting from scratch. Those with existing networks risk ending up with two parallel technology stacks: one open for 5G, and another based on closed, proprietary technologies for earlier network generations.

Parallel Wireless reports that operators that modernize their legacy architecture with Open vRAN expect to see a return on investment in three years[12]. Operators who do not modernize their legacy networks may see operational expenditure (OPEX) costs from 30 through 50 percent higher than the competition, Parallel Wireless estimates[13].

3 years

Time taken to see return on investment from modernizing legacy networks to Open vRAN.

Parallel Wireless[14]

Conclusion

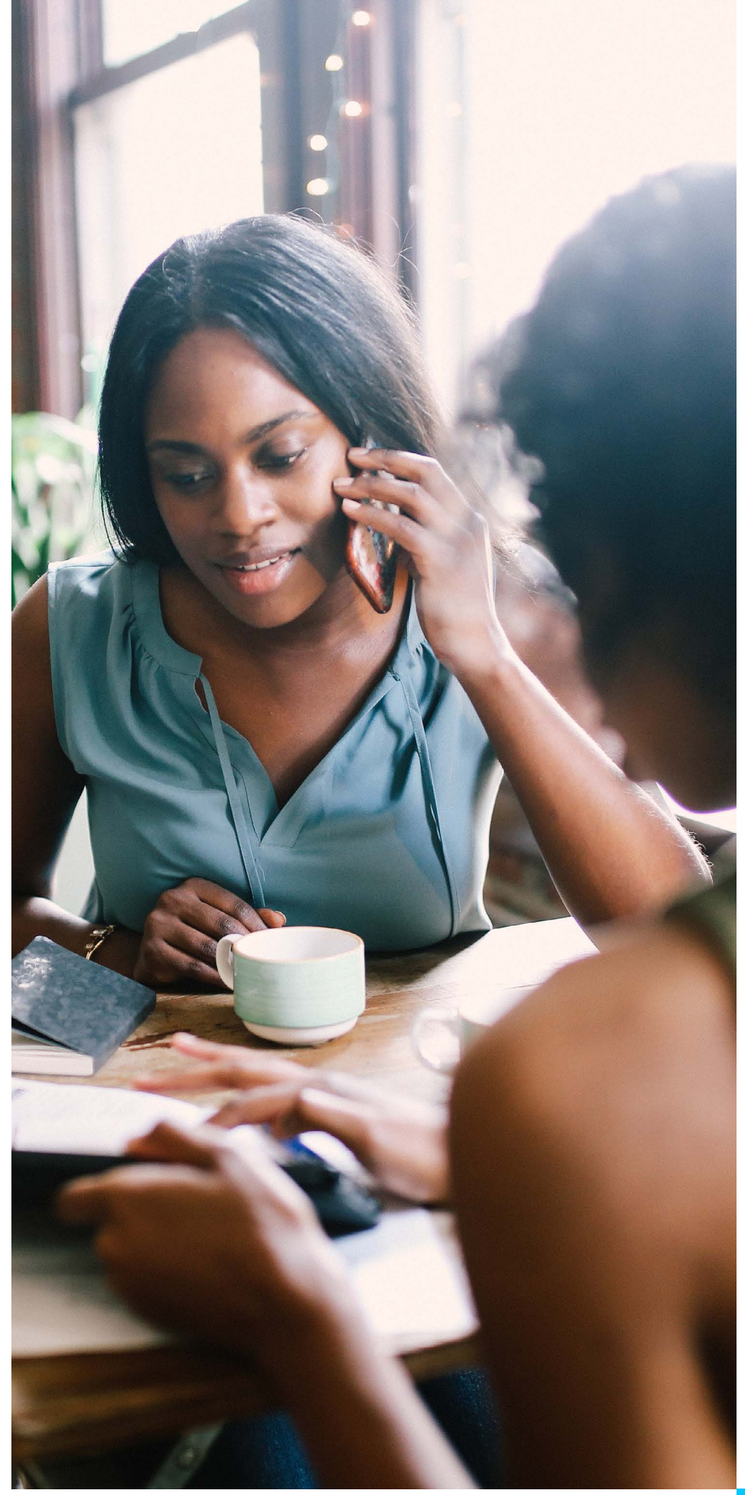
CoSPs are increasingly adopting Open vRAN to improve the flexibility, scalability, and cost-effectiveness of their networks. Research from ACG Research and Parallel Wireless shows that the more widely Open vRAN is deployed, the greater an impact it can have on reducing costs.

CoSPs are adopting Open vRAN for strategic reasons, too. It gives the network cloud-like flexibility and increases the CoSP's negotiating power when sourcing RAN components. In sites where pooling does not demonstrably lower costs, there are still savings from using a consistent technology stack at the radio site and in the centralized RAN processing locations. Having general-purpose compute at the edge of the network can help CoSPs to compete with cloud service providers for edge workloads.

Intel is working with leading CoSPs to model the TCO of Open vRAN. Our TCO model aims to help CoSPs to optimize the cost and flexibility of their RAN estate.

Learn more

- Intel eGuide: Deploying Open and Intelligent RAN
- Intel Infographic: Cloudifying the Radio Access Network
- What's the Best Way to Get to Open RAN?
- How Much Can Operators Save with a Cloud RAN?
- Economic Advantages of Virtualizing the RAN in Mobile Operators' Infrastructure
- What Happens to Deployment TCO when Mobile Operators Deploy OpenRAN Only for 5G?
- Intel® Smart Edge Open



[1] Open RAN Set to Capture 10% of Market by 2025, 2 September 2020, SDX Central; based on data from Dell'Oro Group press release: Open RAN to Approach Double-Digit RAN Share, 1 September 2020.

[2] Technology, Media, and Telecommunications Predictions 2021, 7 December 2020, Deloitte

[3] Virtualized RAN – Vol 1, April 2021, Samsung

[4] Virtualized RAN – Vol 2, April 2021, Samsung

[5] What's the Best Way to Get to Open RAN?, 2021, Mavenir

[6] ibid

[7] How Much Can Operators Save with a Cloud RAN?, 2017, Mavenir

[8] Economic Advantages of Virtualizing the RAN in Mobile Operators' Infrastructure, 30 September 2019, ACG Research and Red Hat

[9] Facebook, TIP Advance Wireless Networking With Terragraph, 26 February 2018, SDX Central

[10] Accenture Strategy, 2019, as reported in Open RAN Integration: Run With It, April 2020, iGR

[11] Goldman Sachs Global Investment Research, 2019, as reported in Open RAN Integration: Run With It, April 2020, iGR

[12] What Happens to Deployment TCO when Mobile Operators Deploy OpenRAN Only for 5G?, 22 May 2020, RCR Wireless

[13] ibid

[14] ibid

Notices & Disclaimers

Intel technologies may require enabled hardware, software or service activation.

No product or component can be absolutely secure.

Your costs and results may vary.

Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

0821/SMEY/CAT/PDF ♻ Please Recycle 348227-001EN